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3 Crown Weights in Red Pine Plantations

Red pine plantations represent a large concentration of fuels associated with relatively high forest investments. These fuels are present from the ground to the treetops. They consist mainly of dead needles, woody and herbaceous vegetation, dead branches, and green crowns (fig. 1).

Fuel weight is an important basic fire behavior consideration. Determining fuel weight on specific areas will provide for more adequate hazard reduction measures, indicate potential energy release on fires, and help predict possible blowup fire conditions. A previous Station Paper has described weights of dead branches and surface fuels in red pine plantations.[1]

The study discussed in this paper was undertaken to determine the crown weights of red pine at different tree diameters, and the influence of different conditions of site and density on the weight of individual crowns.

In plantations on the Lower Michigan National Forest, trees ranging from 2 to 9 inches d.b.h. were selected for crown weight measurements. Weight of the overstory for this range of diameters was studied on good and poor sites in high- and low-density stands.

All live branches on each sample tree were cut and weighed. On representative trees in each diameter class, needles were stripped from one branch per whorl and weighed to provide an estimate of needle weight per tree. Green weights were reduced to dry weights, using a moisture content of 110 percent — an average based on moisture content of needles and branchwood from the sample trees.

For purposes of this study, a site index of 68 or greater was considered good, and one of 52 or less was considered poor. The diameter distributions for stand densities

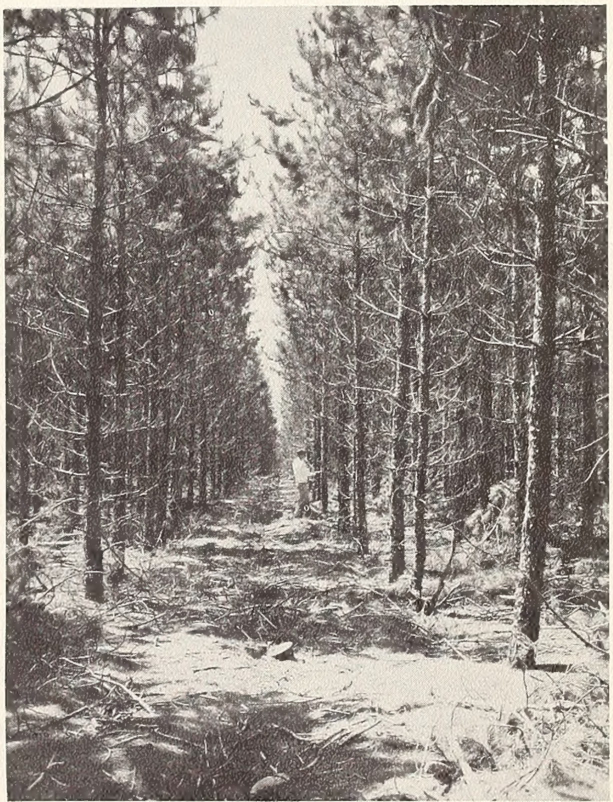

FIGURE 1. — This high-density red pine plantation is growing on a good site. Needles on the ground, dead branches, and green crowns make up the major fuel components. One acre contains approximately 29,100 pounds (dry weight) of live pine crowns.

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[1] *LaMois, Loyd. Fire fuels in red pine plantations. U.S. Forest Service, Lake States Forest Expt. Sta., Sta. Paper 68, 19 pp., illus. 1958.*

sampled in this experiment on both good and poor sites are tabulated below:

Diameter distribution (d.b.h.)	*High-density stands (No. trees/acre)*	*Low-density stands (No. trees/acre)*
2 to 4	1190	550
5 and 6	980	400
7 to 9	690	440

The highly significant regression of crown weight on d.b.h. shows that there are differences in crown weight per tree at different sites and levels of density (fig. 2). For trees of the same d.b.h., individual crowns on good sites weigh more than crowns on poor sites, and crowns from low-density stands weigh more than crowns from high-density stands. A summary of crown weight per tree is shown in table 1.

The quantity of slash resulting from a cutting operation can be determined by first obtaining a good estimate of site and density from which crown weight per tree is calculated, using figure 2. Next, the number of trees harvested in each diameter class is multiplied by the appropriate crown weight per tree. This result is summed through diameter classes to obtain total crown weight for the operation. Whenever a stand falls in the middle of either the site or stand density ranges, crown weight per tree may be interpolated from figure 2.

A more convenient, though somewhat less accurate, method of estimating fuel weight in tree crowns is to use cordwood volume as a predictor of crown weight. Using figure 3,

TABLE 1. — *Crown weight per tree by d.b.h. and stand condition (in pounds, dry weight)*

Site and density	DBH (inches)		
	4	6	8
Good site, high density	22	36	60
Good site, low density	36	54	82
Poor site, high density	13	28	59
Poor site, low density	23	42	75

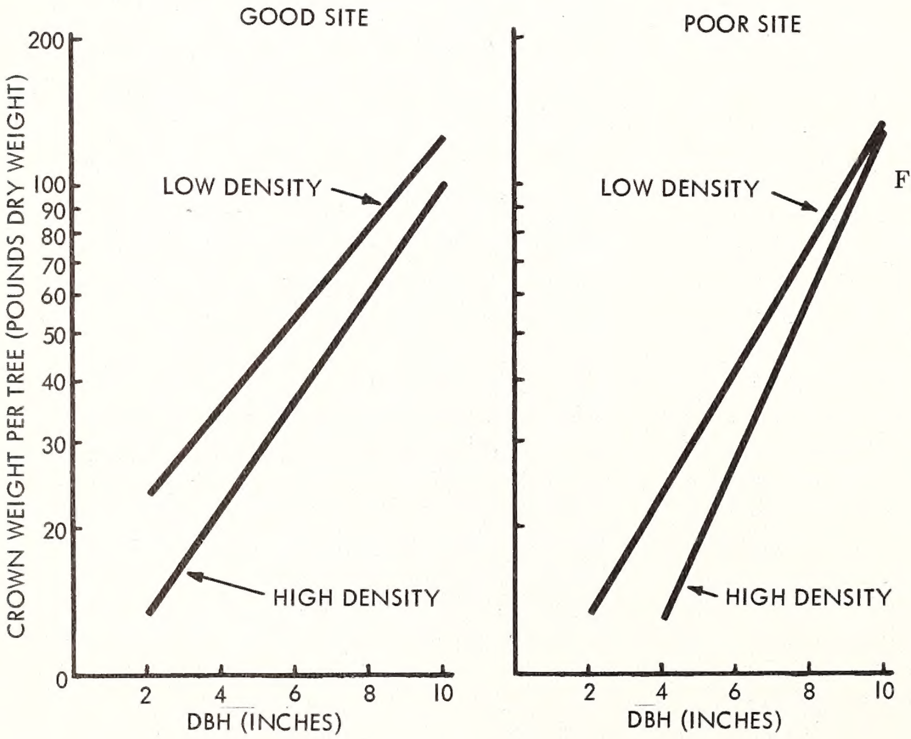

FIGURE 2. — Crown weight per tree for different site and density conditions. Equations for each site according to density conditions are as follows (Lc = log of crown weight per tree; D = d.b.h.; ** = highly significant regression):

A. Good site, low density: $Lc. = 1.1967 + .0893D^{**}$, $r^2 = .77$

B. Good site, high density: $Lc. = .9072 + .1087D^{**}$, $r^2 = .91$

C. Poor site, low density: $Lc. = .8590 + .1269D^{**}$, $r^2 = .92$

D. Poor site, high density: $Lc. = .4394 + .1666D^{**}$, $r^2 = .93$

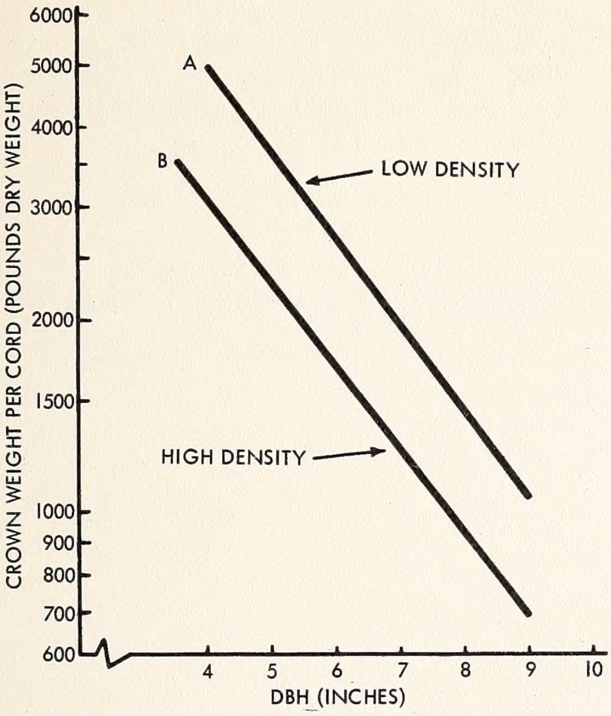

FIGURE 3. — Crown weight per cord on good sites at different densities. Equations for each density condition are as follows (Lc.cd. = log of crown weight per cord; D = d.b.h. ** = highly significant regression):

A. Low-density condition:
$\text{Lc.cd.} = 4.2436 - .1358D^{**}$, $r^2 = .57$

B. High-density condition:
$\text{Lc.cd.} = 4.0013 - .1293D^{**}$, $r^2 = .78$

the quantity of crown weight produced per cord can be estimated, knowing the average d.b.h. of harvested trees and the relative stand density. If stand density falls between the high and low standards, interpolation of crown weight will improve the results. This method is more accurate if the harvested trees are of a uniform diameter.

Crown weight per cord varies considerably with different stand densities and average diameters. The following tabulation shows the weight (in pounds) of tree crowns to be expected from cutting one cord of wood on a good site under different density conditions:

	DBH Class (inches)		
Density	*4*	*6*	*8*
Low	5,012	2,684	1,436
High	3,049	1,681	927

Weight of the overstory for larger cordwood volumes may be obtained by multiplying number of cords times crown weight in proper diameter and density classes in the tabulation above.

An explanation of the variables used for regression analysis in figure 3 may be of interest. Diameter (d.b.h.) was measured on each sample tree. Crown weight per cord was obtained by first determining the cordwood volume in each sample tree, next calculating the number of trees per cord (1.0 divided by cordwood volume per sample tree), then multiplying this value times the crown weight per tree. Volume for each sample tree was determined from a cordwood volume table based on a 3-inch merchantable top.[2]

The weight of needles per crown expressed as a percent of total crown weight with 95-percent confidence intervals is shown below for each of four stand conditions:

Stand condition		*Percent of crown weight in needles*	
Site	*Density*	*Mean*	*Confidence level*
Good	High	51	47-55
	Low	42	34-50
	High and low	46	39-53
Poor	High	43	38-48
	Low	38	33-43
	High and low	41	36-46
Good and poor	High and low	43	40-46

In good-site, high-density stands, approximately 50 percent of the crown weight is in needles. Poor-site, low-density stands may have only 38 percent of their crown weight in needles. A representative estimate for all sites and densities would be approximately 43 percent of crown weight in needles, the remaining 57 percent being in branchwood and top, excluding the stem of the tree.

Fire behavior is dependent upon the interaction of many factors. The primary influence comes from weather conditions associated with the quantity, composition, and continuity of fuels. Knowledge of crown weights furnishes a way of estimating the amount of overstory fuel in uncut stands as well as the amount of slash created by thinning or harvest cuttings. These estimates of weight, together with knowledge of other fire influences, will provide for more accurate prediction of fire behavior.

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[2] *Gevorkiantz, S. R., and Olsen, L. P. Composite volume tables for timber and their application in the Lake States. U.S. Dept. Agr. Tech. Bul. 1104, 51 pp., illus. 1955.*

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JAMES K. BROWN, Research Forester